Ollscoil na hÉireann, Gaillimh

National University of Ireland, Galway

Semester I Examinations 2007 / 2008

Exam Code(s)	4IF, 4BP, 3BA, 1SD
Exam(s)	4th Year B.Sc. (Information Technology) 4th Year B.E. (Electronic & Computer Engineering) 3rd Year B.A. (Information Technology) Higher Diploma in Applied Science (Software Design & Development)
Module Code(s)	CT404, CT336
Module(s)	GRAPHICS AND IMAGE PROCESSING
Paper No.	
Repeat Paper	
External Examiner(s)	Prof. J. Keane Prof. S. McClean
Internal Examiner(s)	Prof. G. Lyons Dr. S. Redfern
Instructions:	Answer **any three** questions. All questions carry equal marks.
Duration	**2 hours**
No. of Pages	6
Department(s)	Information Technology
Course Co-ordinator(s)	

Requirements:

MCQ
Handout
Statistical Tables
Graph Paper
Log Graph Paper
Other Material

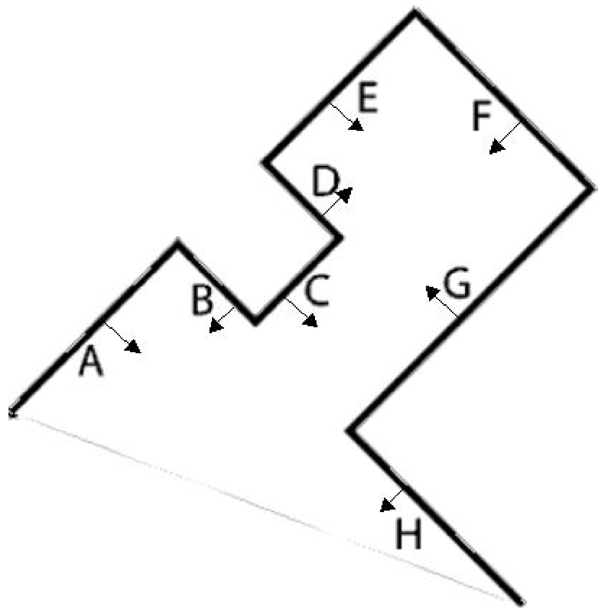
Q.1.

(a) Many of the techniques used in real-time 3D graphics programming attempt to maximise the realism of the rendered scene while using a minimal number of polygons. With specific reference to this ‘polygon budget’, and using diagrams where appropriate, discuss each of the following five techniques:

- (i) Back-face culling (*2 marks*)
- (ii) Texture mapping (*2 marks*)
- (iii) Bump mapping (*2 marks*)
- (iv) Skyboxes (*2 marks*)
- (v) Billboards (*2 marks*)

(b) The Binary Space Partitioning (BSP) algorithm is widely used in modern graphics programming.

- (i) In what situation is the BSP approach most useful? In what situation is it not useful at all? (*2 marks*)
- (ii) Consider the diagram below, which depicts a simple 2D scene involving 8 polygons. The polygons are labeled A through H and the arrows indicate their *surface normals.* Construct a BSP tree for this scene, and briefly explain your steps in constructing it. (8 *marks*)



Q.2.

(a) With respect to the digital storage of raster (bitmapped) graphics, explain the difference between "lossless" compression and "lossy" compression. Briefly outline the dictionary-based LZW compression algorithm used in GIF image files. What characteristics would you expect to see in an image that is highly suitable for GIF compression? *(5 marks).*

(b) Extrusion

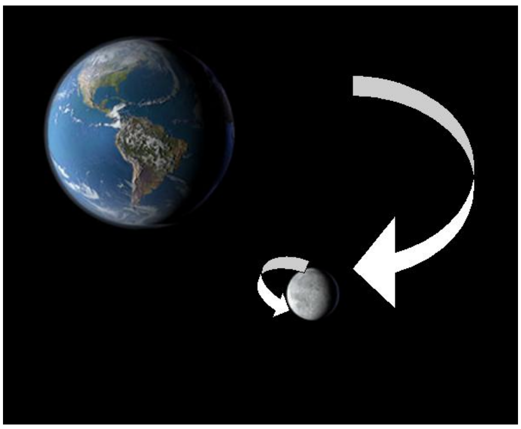
(i) Describe the use of extrusion in VRML, referring to each of the seven fields used by the Extrusion node. (*4 marks*)

(ii) Write VRML code to produce an extruded vase shape, similar to the one shown below. You should consider its geometry only, and can ignore the use of materials. Note that the most useful VRML nodes, as well as a cross section for this vase, are summarised on the final page of this exam paper. (*4 marks*)

```
Extrusion
{
  crossSection [ ]
  spine        [ ]
  scale        [ ]
  orientation [ ]
  beginCap
  endCap
  creaseAngle
}
```

(c) VRML textures and animation

Write VRML code to produce an animation of a moon moving around a static earth. You should assume that two jpeg files "earth.jpg" and "moon.jpg" have been provided for you to texture map onto two spheres. The moon should rotate on its own axis as well as around the earth. Note that the most useful VRML nodes are summarised on the final page of this exam paper. *(7 marks).*



Q.3.

The C++ code on this page provides a skeleton 3D OpenGL/GLUT program.

(a) Using only polygons (rather than GLUT or GLU primitives), extend the display( ) function in order to display a solid cube at the centre of the world (*6 marks*)

(b) Extend the init( ) function to define a light, and a red material for the cube (*6 marks*)

(c) Further extend the display( ) function to animate the cube so that it rotates around its own centre (*8 marks*)

```
#include <GL/glut.h>

void init(void) {
  glClearColor (0.0, 0.0, 0.0, 0.0);
  glShadeModel (GL_SMOOTH);
  glEnable(GL_DEPTH_TEST);

   // lights and materials code needed here -------

}

void display(void) {
  // rendering code needed here ------------------

}

void reshape (int w, int h) {
   glViewport (0, 0, (GLsizei) w, (GLsizei) h);
   glMatrixMode (GL_PROJECTION);
   glLoadIdentity();
   if (w <= h)
      glOrtho (-1.5, 1.5, -1.5*(GLfloat)h/(GLfloat)w,
         1.5*(GLfloat)h/(GLfloat)w, -10.0, 10.0);
   else
      glOrtho (-1.5*(GLfloat)w/(GLfloat)h,
         1.5*(GLfloat)w/(GLfloat)h, -1.5, 1.5, -10.0, 10.0);
   glMatrixMode(GL_MODELVIEW);
   glLoadIdentity();
}

int main(int argc, char** argv) {
   glutInit(&argc, argv);
   glutInitDisplayMode (GLUT_SINGLE | GLUT_RGB | GLUT_DEPTH);
   glutInitWindowSize (500, 500);
   glutInitWindowPosition (100, 100);
   glutCreateWindow ("OpenGL");
   init ();
   glutDisplayFunc(display);
   glutReshapeFunc(reshape);
   glutMainLoop();
   return 0;
}
```

Q.4.

(a) Many automatic image analysis algorithms begin by smoothing an image, and then applying an edge extraction filter in order to ascertain the evidence for the edges of objects in the image. (i) Discuss the use of smoothing and edge detection for these purposes. (ii) Discuss some approaches that might be used to deal with problems such as fragmentary edges and occluded edges. *(10 marks).*

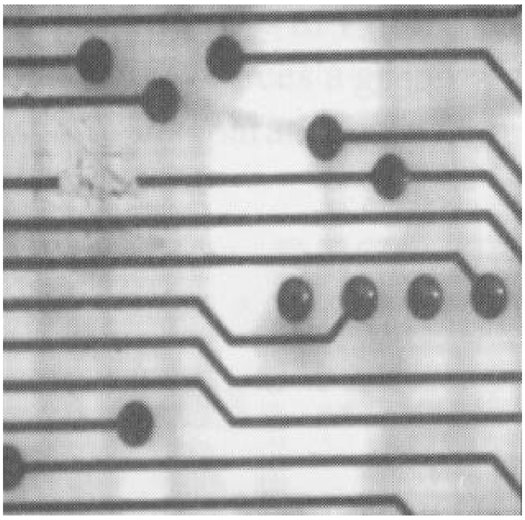
(b) Explain the keyframe approach to animation in computer graphics, and explain its use in VRML, referring to the TimeSensor, Transform, OrientationInterpolator and PositionInterpolator nodes in your answer. (*5 marks*)

(c) A more powerful approach to producing animations in VRML is to use JavaScript nodes to dynamically calculate key positions or orientations. Write VRML code for a JavaScript node which produces elliptical motion, and which is suitable for use with a TimeSensor and a Transform node (*5 marks*).

Q.5.

(a) Describe the morphological techniques of erosion and dilation. Compare the four operations (i) opening, (ii) closing, (iii) thinning and (iv) thickening. In what circumstances might each of these four operations be used? *(10 marks).*

(b) The image on the right is of a printed circuit board (PCB), thousands of which are manufactured every hour in a particular factory. It is required as part of the quality control of this factory to produce an automatic machine vision system, which extracts the traces (straight bits), end points (places at which a trace terminates), and pads (circular bits) in the image. **Present** and **discuss** a suitable and robust set of image processing algorithms for this task *(10 marks).*



Some useful VRML node information:

```
Shape
{
      geometry
      appearance
}

Transform
{
  children    [ ]
  translation 0.0  0.0  0.0
  rotation    0.0  0.0  1.0  0.0
  scale       1.0  1.0  1.0
  center      0.0  0.0  0.0
}

TimeSensor
{
  enabled            TRUE
  startTime          0.0
  stopTime           0.0
  cycleInterval      1.0
  loop               FALSE
  isActive           # eventOut
  time               # eventOut
  cycleTime          # eventOut
  fraction_changed   # eventOut
}

PositionInterpolator
{
  key   [  ]
  keyValue [  ]
  set_fraction   # eventIn
  value_changed  # eventOut
}

OrientationInterpolator
{
  key   [  ]
  keyValue [  ]
  set_fraction       # eventIn
  value_changed      # eventOut
}

Extrusion
{
  crossSection [ ]
  spine       [ ]
  scale       [ ]
  orientation [ ]
  beginCap
  endCap
  creaseAngle
}
```

```
Box
{
      size 2.0 2.0 2.0
}

Sphere
{
      radius              1.0
}

Cylinder
{
      radius              1.0
      height              2.0
      side                TRUE
      top                 TRUE
      bottom              TRUE
}

Appearance
{
      material
}

Material
{
      diffuseColor
      specularColor
      ambientIntensity
      emissiveColor
      transparency
      shininess
      texture
}

ImageTexture
{
      url
}
```

Co-ordinates for a circle-shaped cross section, suitable for extrusion:

```
1.00 0.00,    0.92 -0.38,
0.71 -0.71,   0.38 -0.92,
0.00 -1.00,   -0.38 -0.92,
-0.71 -0.71,  -0.92 -0.38,
-1.00 0.00,   -0.92 0.38,
-0.71 0.71,   -0.38 0.92,
0.00 1.00,    0.38 0.92,
0.71 0.71,    0.92 0.38,
1.00 0.00
```